The results of the studies of the phase structure of polymer layers of elasticized composites show that the use of finishing and a sublayer permit eliminating the negative effect of the metal on the process of formation of the disperse phase of elasticizer and results in a significant increase in the crack resistance of boundary layers of elasticized binders with the surface of the metallic substrate.

Increasing the degree of the elasticizing effect in polymer layers of adhesive systems and PCM based on highly polar fillers and substrates can thus optimize the phase structure of elasticized binders in the region of the adhesive contact due to the use of finishing and transitional polymer layers.

LITERATURE CITED


PARAMETERS OF FAILURE OF ADHESIVE JOINTS IN SYMMETRIC PEELING

V. I. Pavlov and V. D. Galich

One of the common and dangerous types of failure of adhesive joints (AJ) is peeling of one element of the joint from the other. The external loads concentrated in a narrow band of the region of peeling create stresses in it sufficient for failure of the adhesive contact even with low values of these stresses. This type of failure is observed in using coatings, adhesive compounds, laminated, and composite materials. The process of failure of the AJ in peeling in controlled conditions is also realized in standard methods of determining the adhesive strength [1-3], but a disadvantage of these methods is the dependence of the results of the determination on a number of methodological factors. For this reason, the study of the mechanics of failure of AJ on peeling is important both for the development and effective use of new composite materials, articles, and constructions made of them, and for improving the methods of adhesion testing.

At the same time, insufficient attention has been focused on this question in the literature, apparently due to the methodological difficulties in the experimental study of this type of failure. The process of failure of the AJ on separation of the free end of the peeled material from the flat substrate at a constant rate in conditions of respecting a con-
TABLE 1. Characteristics of the Objects of Investigation and Parameters of Their Failure in Symmetric Peeling

<table>
<thead>
<tr>
<th>Object</th>
<th>Coating</th>
<th>Substrate</th>
<th>Young's modulus of elasticity E, MPa</th>
<th>Adhesive strength on peeling (according to GOST 4117-74) C, N/m</th>
<th>Established angle α, deg</th>
<th>Established peeling force F, N</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Stencil Printing ink ST 3.8-01 based on S-840 cyclorubber and tung oil (18±0.5) μm thick according to GOST 29-02-800-80</td>
<td>Paper with B 3-1 silicon layer (70±2) μm thick according to TU 29.01. 11-83</td>
<td>86.0</td>
<td>5.7</td>
<td>16</td>
<td>0.37</td>
</tr>
<tr>
<td>II</td>
<td>Butadiene-styrene thermoplastic BST30-58 (50±2) μm thick according to TU 38.103267-80</td>
<td>Brand E polyethylene terephthalate film (120±10) μm thick according to GOST 24234-80</td>
<td>0.8</td>
<td>129.0</td>
<td>85</td>
<td>1.50</td>
</tr>
</tbody>
</table>

constant angle of peeling equal to 90° is examined more frequently than others in [1-5]. One parameter of failure is usually measured: the peeling force, which is unambiguously related to the adhesive strength, since it is also dependent on the testing conditions, and indexes of the cohesion and stiffness of the peeled material. The impossibility of peeling stiff materials and the difficulty of rigorously maintaining the constancy of the direction of the effect of the breaking load with respect to the plane of the adhesive contact whose failure results in a change in the peeling force and instability of the failure process are the basic disadvantages of this scheme of failure of AJ.

It follows from the above that these conditions of testing AJ in studying the peeling process are limited and can be qualified as a special case in which many aspects of the process of failure related particularly to a change in the angle of peeling are excluded from the examination. The analysis of the studies cited permits concluding that one measurable parameter of failure (peeling force) cannot sufficiently determine this complex type of failure of AJ.

In this respect, a symmetric peeling scheme was proposed and examined in the present study for investigating the process of failure of an AJ of the coating-substrate type. It permits characterizing the process of failure by two parameters: the force and angle of peeling, determined in simultaneous separation of two symmetric bands of coating from a flat substrate at a constant rate with force normal to the plane of the adhesive contact.

The process of failure was studied on objects with a weak adhesive interaction of the coating with the substrate primarily ensured by the adhesive character of failure on the phase boundary. Silicone and polyethylene terephthalate substrates were used as the substrates, and paint and varnish materials used in special types of printing for production of dry transfer images were used as the coatings [6]. Their characteristics are reported in Table 1. Failure of the AJ was induced on a universal instrument for physical-mechanical tests [7] with a mobile clamp movement rate of 0.83 mm/sec. Samples of the coatings were prepared for testing on substrates with a width of 10 and a length of each symmetric band of 60 mm. The coating was applied to the substrate and its thickness was varied by the stenciling method in [8]. The scheme of failure of AJ in symmetric peeling is shown in Fig. 1. The number of successive stages of peeling of the strips of coating combined in one image is indicated by the broken lines.

The sample studied consisted of two strips of coating 1 of the same width and thickness on substrate 2, attached from the substrate side to stand 3 with double-sided adhesive tape previously peeled by the free ends so that their longitudinal axes of symmetry lay on the same line. The stand was positioned horizontally to lower (mobile) clamp 4 of the instrument so that the plane of the adhesive contact would be perpendicular to the direction of loading. The free ends of both strips were held in upper clamp 5, connected with force gauge by rod 7. To prevent the strip of coating from bending in the starting position, the lower plate of the upper clamp was sunk in slot 8 of the stand.

The test consisted of moving the lower clamp with the stand relative to the upper clamp with the attached free ends of the strips of coating in the direction of the arrow V with